VISUAL AIDS IN THE TEACHING OF GENETICS

Marjorie E. Smith

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Service Paper

VISUAL AIDS IN THE TEACHING OF GENETICS

by
MARJORIE E. SMITH

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CHAPTER I

STATEMENT OF THE PROBLEM

INTRODUCTION

The entire field of genetics and heredity is a fascinating one. The microscope, the electron microscope, and the patient research of many talented scientists have revealed some of the secrets contained within the walls of the cell. Not content with the limitations of the nucleus of the cell, science has probed through its chromosomal pairs into the tiny, microscopic, darkened structures known as the genes, in an effort to discover more about these hereditary factors which play such an important part in the lives of mankind.

Line and color are an effective way to visually present a subject. Dale bases his book upon the principle "that all teaching, from the first grade through the college level, can be greatly improved by visual and auditory materials because these teaching materials can make the learning experience far more concrete and memorable."[1] The teacher uses visual and auditory techniques as a powerful means of achieving her

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[1]Edgar Dale, Audio-Visual Methods In Teaching, The Dryden Press, Inc., N. Y., 1949, p. 6.

major purpose, that of good teaching.[1] The present paper is concerned with using this method on slides to present the study of genetics more easily and clearly to high school students after they have had an introduction to the method and factors of inheritance.

The problem and purpose of this paper is to use line drawing and color on Slidecraft slides to depict the method of visible inheritance with animation so it can be understood more easily. Slidecraft slides are slides for use in a stereopticon--pencil, ink, or crayons may be used on them. They can be ordered from Meadows A.V.C. Service, 142 Morris Avenue, Mountain Lakes, New Jersey.

Justification of the problem is aptly phrased by Edgar Dale.

> "It may be worth pointing out an intrinsic advantage of the projected glass slide or filmstrip: magnification. Though the pupil handles no material and is merely a spectator, he nevertheless experiences the view with more intensity. The image is large and impressive and the darkened room removes distractions and enables him to focus his attention on the subject itself."[2]

The advantages of projected material are several.[3] A large group can see it at the same time. The magnification often helps to get the idea across in addition to holding the attention of the group as a whole. It also makes variation in the routine teaching possible.

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[1]Edgar Dale, Audio-Visual Methods In Teaching, p. 7

[2]Ibid., p. 45.

[3]Ibid., p. 222.

DEFINITIONS

Gene--"An independently inheritable element by the presence of which some particular character in the organism is made possible; factor."[1]

Factor--"Latent physiological units which upon crossing give rise to the new characters found in the hybrid."[2]

Alleles--A term that applies "to the members of a pair of contrasting factors."[3]

Multiple alleles--A set of alleles that contains more than two factors; "three, four, and even as many as eleven members."[4]

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[1]Funk & Wagnalls, New Standard Dictionary, Funk & Wagnalls Co., N. Y., 1944, p. 1018.

[2]Ibid., p. 888.

[3]Laurence H. Snyder, The Principles of Heredity, p. 105.

[4]Ibid.

CHAPTER II

SELECTION OF THE PROBLEM

This problem is concerned with developing a method to effectively present some of the visible effects of inheritance factors in genetics on Slidecraft slides.

Since high school students are interested in their own growth, at a time when they are developing mentally and physically, they ask many questions. How did Mary inherit blonde hair when her parents have dark hair? Why does James have blue eyes when his parents are both brown-eyed?

There is a real need of making the nature of inheritance clearer. One way, which has not been used to the knowledge of the writer, is by line drawing and animation on Slidecraft slides. This will fill a need, in part, by making the subject of genetics easier to comprehend. It will also give a new approach to the subject matter.

The problem will be limited to a study of materials and literature in the field of genetics and heredity for items which are suitable and capable of being portrayed pictorially. The final results of this material will be used to develop a set of Slidecraft slides for use in teaching inheritance.

A review of the literature on this subject has not revealed any material in the field of genetics which has been depicted in the medium of Slidecraft slides. Standard sources for previous studies and the history of research in this phase of genetics, such as the Education Index and the Readers' Guide, are conspicuous by the absence of references in this area. A survey of the field has failed to show any evidence of the teaching of heredity that included material which has been animated on Slidecraft slides.

CHAPTER III

RESEARCH PROCEDURE AND PRESENTATION OF DATA

This chapter will largely be devoted to a description of the material as it is illustrated in the accompanying drawings, for use on Slidecraft slides, and, as it could be presented when the actual slides are used in the classroom.

The research procedure involved four steps. First, a survey of available literature on genetics and heredity was made for material which showed the inheritance of visible factors, such as, eye color, albinism, etc. From this material a selection of those factors which could be adapted for illustration was made. These factors were then drawn with animation applied to the drawings depicting the method of inheritance. The final drawings were made on Slidecraft slides, which permit of convenience in showing the material to a group and ease in transporting or storing it.

This research procedure was based on several data. It was necessary to know what is generally presented to high school students in the study of heredity, what the method of inheritance is, and what inheritance factors are appropriate for illustration.

Data were procured by an examination of high school textbooks, selected at random, to see what they present in the study of heredity. The method of inheritance was obtained from the same sources as well as in books on inheritance or genetics.

After the data had been gathered, it was examined as to its suitability for illustration. The drawings have been kept as simple as possible so the main ideas will stand out. The drawings can be easily transferred to Slidecraft slides(or ground glass slides) by placing the slide over the drawing and carefully tracing it with a lead pencil. Color may be added, if desired.*

This paper has been based upon the following assumptions:

1. It has been assumed that the principles of mitosis, meiosis, and reduction division are known.
2. It has been assumed that the laws of Mendel are known.
3. It has been assumed that the reader is familiar with the cross between dihybrid peas which are found in practically every book on this subject.

---

*The original set of Slidecraft slides is deposited with Dr. John Read, Boston University, School of Education, 332 Bay State Road, Boston, Mass.

BUILDING STONES OF HEREDITY

> "Evidence has accumulated, mainly since the beginning of the present century, to show that the chromosomes contain the factors of inheritance, each of which enables the organism to develop one or more specific traits; and that these factors, also called genes, are arranged in linear order on the chromosome, much as beads are arranged on a string. The longitudinal splitting of each chromosome and the exact distribution of the halves of each to the two new cells are of special significance in that they insure the transmission to both new cells of all the genes of the old, thus making the new cells true to the type represented by the old."[1]

Figure one, "Genes--Building Stones", is used to introduce the subject of genetics. It shows the chromosomes in pairs, as well as the genes in pairs. "In their linked-together form(the chromosomes) we can think of them as "chain-gangs," twenty-four of these gangs of workers sent along by each parent to construct the individual."[2]

> "Genes are biological architects. Their task is to use material obtained from the environment and build the body according to hereditary blueprints. Every cell in your body contains a full "staff" of 30,000 genes."[3]

It is these genes which influence height, eye color,

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[1]Leslie A. Kenoyer & Henry N. Goddard, General Biology, Harper & Brothers Publishers, N. Y., 1945,p. 375.

[2]Amram Scheinfeld, You and Heredity, J. P. Lippencott Co., N. Y., 1939, p. 45.

[3]John Pfeiffer, Genetics--The Science of Heredity, Public Affairs Phamphlet, N. Y., no. 165, 1950, p. 11.

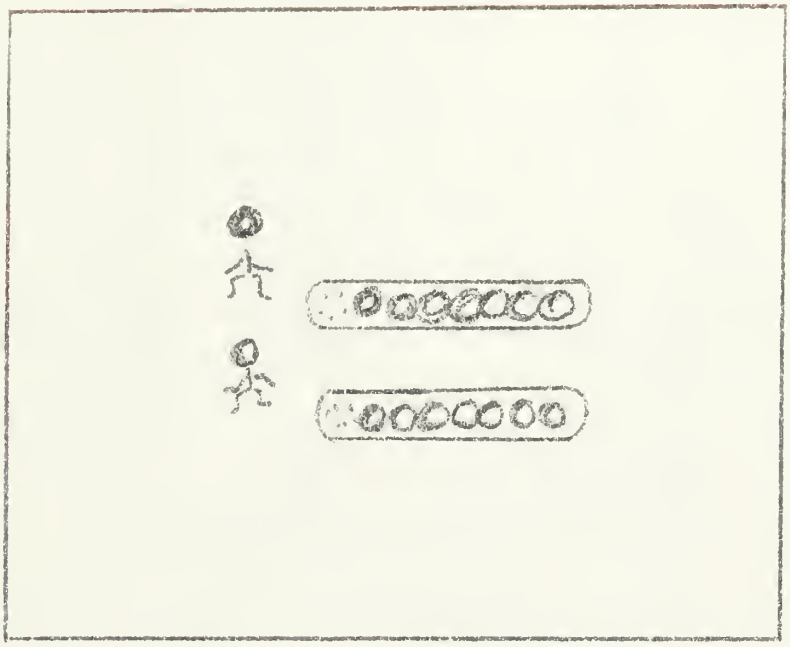

FIGURE 1

Genes--Building Stones

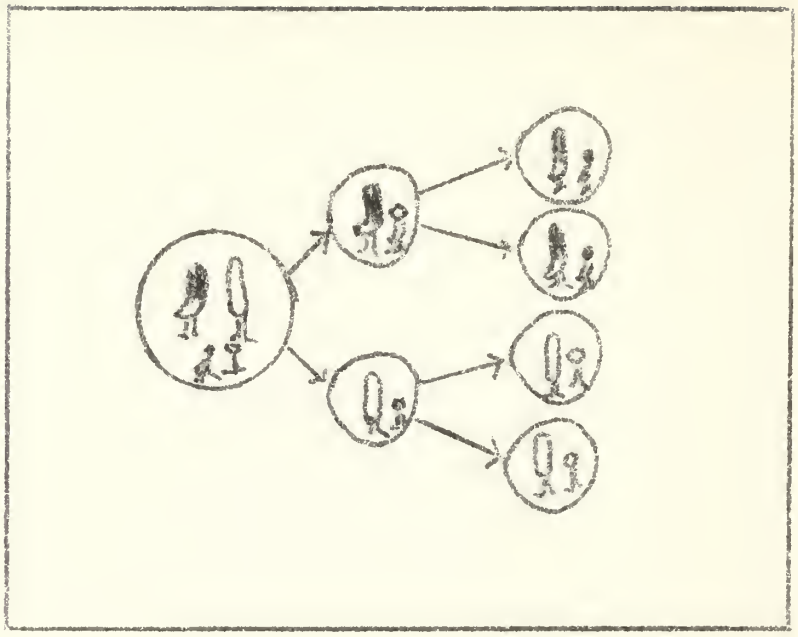

FIGURE 2

Development of Oocyte

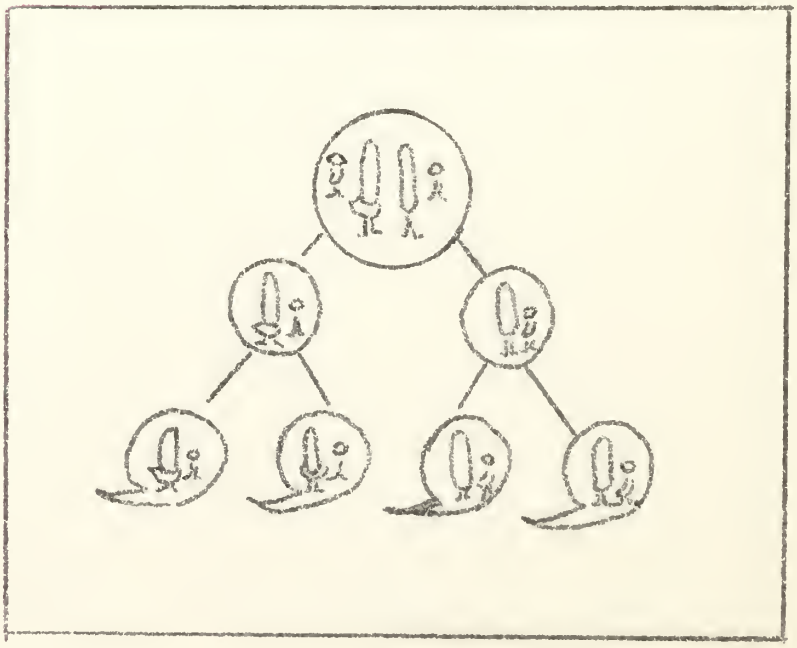

FIGURE 3
Development of Spermatocyte

hair color, hair texture, skin color.[1]

> "Within one family can be found children closely resembling their parents, and those which may suggest a greater similarity to grand parents. We are accustomed to recognizing such likenesses and differences within groups known to have common inheritance . . . A large majority of fundamental similarities such as muscular and nervous structure are found in the human species along with such minor differences as head shape, skin color, facial contours, and blood groups.
>
> "Both the similarities and differences result from the interaction of hereditary determiners(genes) and their environment. A particular pair of genes may influence skin color, but other genes also do; and even if a gene has its major effect on skin color it may likewise influence hair color or eye shape or nearly any part of the body. In other words, the determiners interact with each other to produce their result."[2]

Dominant genes result in the inheritance of pigmented eyes, cataract of the eye, dark hair color; while recessive genes are responsible for such effects as albinism, hereditary deafness.[3]

It is necessary to understand how the hereditary factors are transmitted to the offspring. This is made possible by the maturation of the gametes or reproductive cells by reduction division as illustrated by figures two and three, where the maturation of gametes for female and male, respectively, are shown.

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[1]Charles B. Davenport, Heredity of Skin Color in Negro-White Crosses, Carnegie Institution of Washington, Washington, D. C., 1908, pp. 46-47.

[2]Russell L. Mixter, "Comments on Creation & Evolution," Unpublished paper, Wheaton, Ill., 1947, p. 6.

[3]Leslie A. Kenoyer & Henry N. Goddard, General Biology, p. 512.

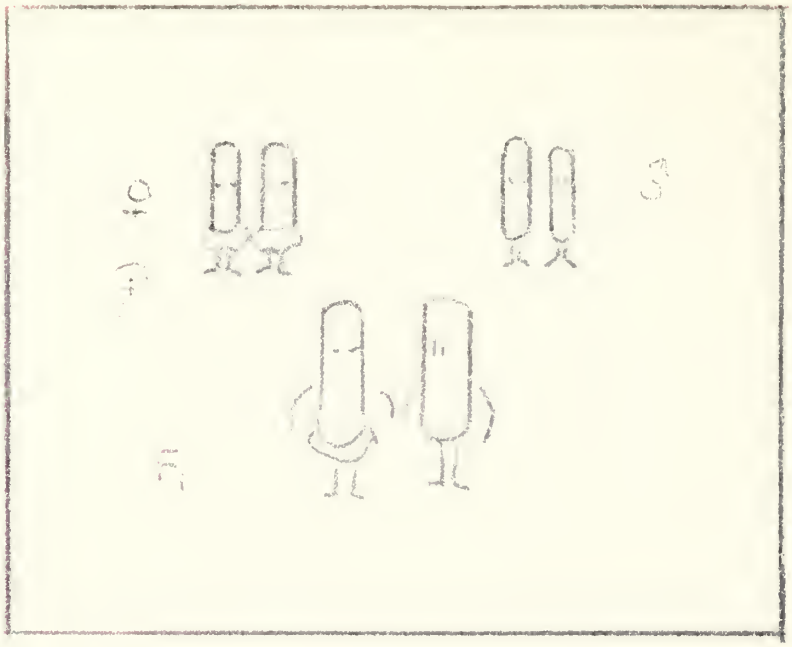

FIGURE 4

Each Parent Contributes One-half of the

Hereditary Factors

Man has forty-eight chromosomes, or twenty-four pairs, having received half of this number from each parent. In reduction division the chromosomes pair off, without spliting, giving each gamete one of each pair or twenty-four chromosomes. This chromosomal number is restored to forty-eight in the fertilized egg, which prevents the doubling of the number of chromosomes at fertilization. In the figures this reducing of the chromosomal number by one-half is seen. The result of fertilization, where one-half the number of chromosomes is donated by each parent, to the new organism is simply illustrated in the drawing of figure four. "Since only half of the chromosomes of each parent are present in the fertilized egg, only part of the qualities of both parents will be inherited."[1]

MENDELIAN INHERITANCE

Gregor Johann Mendel, of Brünn, Moravia, discovered some of the principles of heredity, where he worked and experimented with the garden pea. He discovered that some traits are dominant while others are recessive. He called these traits, "hereditary factors"--geneticists call them genes.[2]

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[1] I. H. GOldberger & Grace T. Hallock, Understanding Health, Ginn & Co., Boston, 1950, pp. 18-19.

[2] Ibid., pp. 17-26.

> "Every animal or plant carries two genes(factors) of each set which is found in the species. This means that if we wrote out the entire genetic formula of an individual it would contain hundreds, perhaps thousands, of pairs of factors. When we make a cross, we consider only the factor pairs in which the individuals in the cross differ, and we leave out all other pairs in order to save space."[1]

Only the factors in which the individuals differ are written down, the rest being left out.

A pair of factors is discovered by noting a normal factor, such as one for color. When an organism is noted without color or pigment, it is learned by breeding tests that the unpigmented condition is due to a recessive factor. Thus the two factors are seen, one for normal pigment, and a recessive one in which it is absent.

How some of these traits or hereditary factors are inherited is shown in the following pages and figures.

Mendeliam two-factor inheritance provides a logical starting point. Mendel found that when he crossed a pea plant, which was homozygous for tallness, with one that was homozygous for dwarfness; the offspring, or F_1(first filial generation), were all tall hybrids.[2] When two of these hybrids were crossed, the offspring, or F_2(second filial

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[1]Laurence H. Snyder, The Principles of Heredity, 3rd edl D. C. Heath & Co., Boston, Mass., 1946, p. 50.

[2]W.D.Meier & Lois M. Shoemaker, Essentials of Biology, Ginn & Co., Boston, Mass., 1938, pp. 637-657.

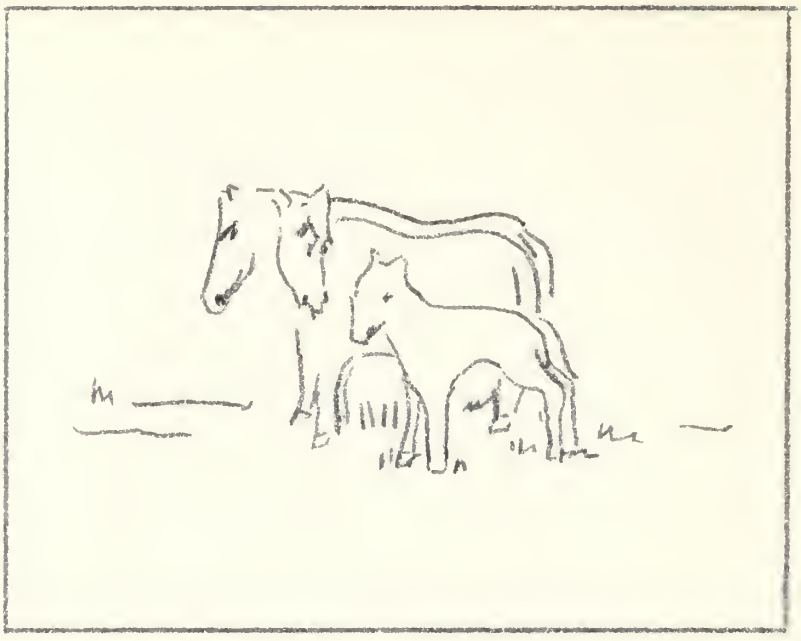

FIGURE 5

Cross: Homozygous Chestnut Horse

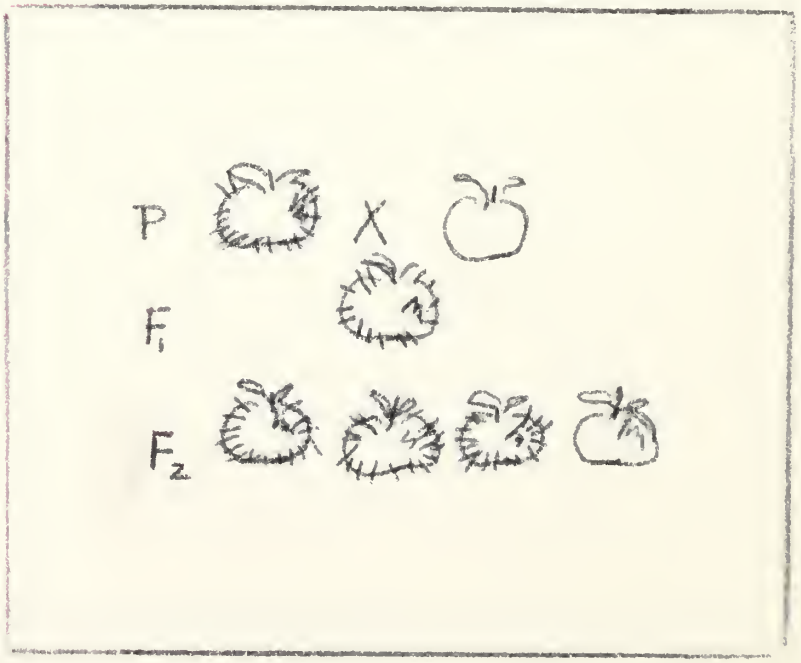

FIGURE 6

Cross: Peach X Nectarine

generation), gave a ratio of three tall to one dwarf. When these F_2 self-pollinated, Mendel discovered that twenty-five per cent of the tall plants produced only tall plants, and the other fifty per cent were hybrids that looked tall but carried a factor for dwarfness. Tallness, which is evidenced when present, was called the dominant gene. Its contrasting allele is the recessive gene which does not show itself unless both genes carry it.[1]

When two horses, homozygous for chestnut color, are mated, all the F_1 are likewise chestnut, due to the dominance of this color.[2] This is shown in figure five.

When a peach with fuzzy skin is crossed with a smooth-skinned nectarine, all the F_1 resemble the peach. If two of the F_1 are crossed, the F_2 result is a ratio of 3:1, with the factor for peach being dominant,[3] as can be noted in figure six.

When two mice, which are heterozygous for fuzzy coat, are crossed, their offspring are in the ratio of three fuzzy to one of normal coat. If one of the heterozygous

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[1]Leslie A. Kenoyer & Henry Goddard, General Biology, p. 381.

[2]Ernest B. Babcock & Roy E. Clausen, Genetics In Relation to Agriculture, McGraw-Hill Book Co., Inc., N. Y., 1918, p. 466.

[3]M. B. Crane & W. J. C. Lawrence, The Genetics of Garden Plants, MacMillan & Co. Ltd., London, 3rd ed., 1947, p. 128.

fuzzy mice is mated to a homozygous fuzzy mouse, the offspring give a 1:1 ratio of fuzzy and normal.[1]

Such a cross of a hybrid with a homozygous individual is called a backcross. It shows whether an organism is a hybrid or runs pure in a certain factor, by a cross of an individual which is heterozygous for the factor with one known to be homozygous recessive for the character involved. If the offspring are all alike, the organism is homozygous: if there is a ratio of 1:1, one-half showing the dominant character and the other half the recessive; then the individual originally crossed was a hybrid.

If a guppy, carrying a recessive factor for lordosis, is crossed with another carrying the same factor, the young guppies will be normal except for twenty-five per cent which will have the dorsoventral curvature.[2]

When a cross is made between horned and hornless cattle, the F_1 are hornless. The characteristic of "horned" doesn't show up until the F_2, when it is observed in one-fourth of them.[3]

Countless more examples could be given of this two-

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[1]George W. Wooley & Margaret M. Dickie, "Fuzzy Mice," Journal of Heredity, July, vol. 41, no. 7, pp. 193-196.

[2]Harold & Rose Rosenthal, "Lordosis, a Mutation in the Guppy, Journal of Heredity, Aug., vol. 41, no. 8, pp. 217-218.

[3]Francis D. Curtis & Otis W. Caldwell, Biology for Today, Ginn & Co., Boston, 1950, p. 626.

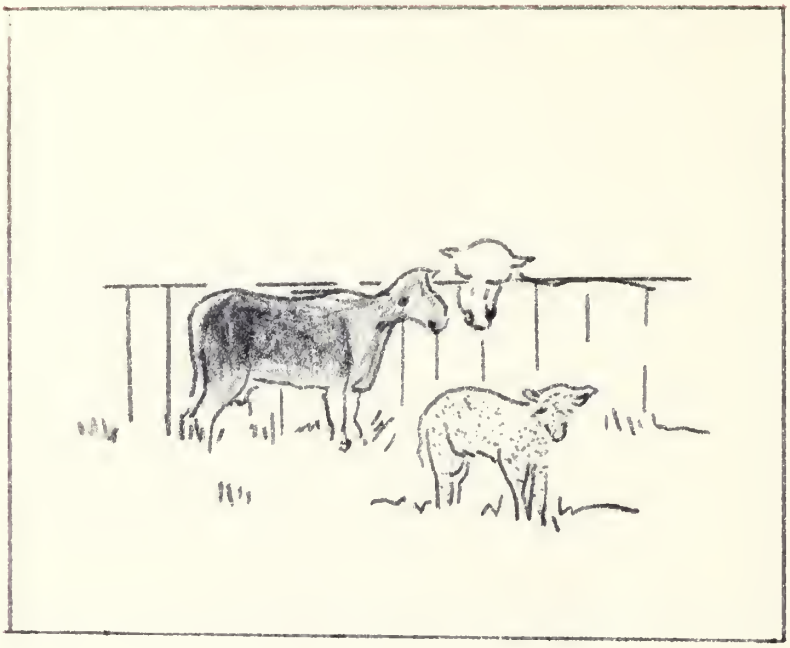

FIGURE 7

Cross: Incomplete Dominance in Cattle

factor inheritance with its 3:1 ratio. It also throws light on the undesirableness of marriage between first cousins.[1] Since they have received their genes from much the same ancestry, they are more likely to carry the same recessive defective genes than two unrelated persons, even if they are normal themselves.

In figure number seven is illustrated a cross between a red cow and a white bull. The calf is roan in color. Since neither red nor white is completely dominant, there is a blending of the two colors in the F_1, which is known as incomplete dominance. When two of these roan cattle are mated, the offspring sort out into a ratio of 1 red: 2 roan: 1 white.[2]

Albinism is an interesting recessive factor. Albino mice were used by the Chinese priests for auguries, and records of thirty of them have been entered into the government records during the years 307-1641 A. D.[3] Complete albinism is a condition in which pigment is entirely wanting in all parts of the body. When two albinos mate, all the offspring are the same as the parents, since there is no gene for pigment. This characteristic has been noted in ani-

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[1]Ella Thea Smith, Exploring Biology, Harcourt, Brace & Co., N. Y., 1948, p. 510.

[2]Laurence H. Snyder, The Principles of Heredity, p. 17.

[3]Clyde Keeler, The Laboratory Mouse, Harvard University Press, Cambridge, Mass., 1931, p. 15.

FIGURE 8

Albino Navaho Girl

FIGURE 9

Black Sheep

mals, birds, and human beings.

The writer has observed albinos among the Hopi and Navaho Indians. An albino girl of the latter tribe had the usual pink skin, near-sighted, light-colored eyes, and long slightly-yellow hair. In figure number eight is shown a Navaho albino. Evidently her parents carried the recessive genes for non-pigment which the child inherited from both. Such individuals are usually looked on favorably. This description agrees with that reported about the Indians of San Blas, Central America. Of 20,100 Indians, 138 albinos were found.[1] Although these albinos are forbidden to marry, albinos have continued to occur in the tribe in considerable numbers for the past three centuries.[2]

The black sheep which is occasionally found in a flock of white ones, is a recessive character like albinism, where white is dominant to black.[3] White sheep carrying this recessive factor could have a black lamb as is shown in figure nine.[3]

Hybrids have been discussed as individuals which had a dominant factor and carried a recessive one. Wild ducks sometimes hybridize with semi-domesticated flocks. A fea-

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[1]William Castle, Genetics and Eugenics, Harvard University Press, Cambridge, Mass., 4th ed., 1930, pp. 354-355.

[2]Ibid.

[3]Laurence H. Snyder, The Principles of Heredity, p. 19.

ture of duck hybrids "is that the characters of the parents, instead of being "blended," usually show distinctly in the pattern of the mongrel bird."[1] Sometimes a parental character, such as the white collar of the mallard, disappears in the F_1 and reappears in males of later generations.

Two pairs of factors can be crossed, which is often illustrated by the dihybrid cross between yellow, smooth corn, and green, wrinkled corn. A cross of this kind, involving two pairs of factors, gives a ratio of 9:3:3:1.

If a pure jet black mouse is crossed with a yellow one, all the F_1 are gray.[2] When two of the F_1 are crossed, the F_2 produce four different colors, with 9 gray, 3 black, 3 yellow, and 1 cream. All these colors are dependent upon the two pairs of factors. The gray of the F_1 is a combined effect of the dominant factor of each pair. The one cream of the F_2 is the effect of both pairs of recessive factors. Thus, it is seen that a certain character, in this case, coat color of the mouse, depends on more than one factor. The "modern genetic belief is that no single factor is solely responsible for the production of any one character."[3]

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[1]Francis H. Kortright, The Ducks, Geese, & Swans of North America, The American Wildlife Institute, Washington, D. C., 1942, p.44.

[2]S. J. Holmes, Human Genetics and its Social Import, McGraw-Hill Book Co., Inc., N. Y., 1936, p. 64.

[3]Laurence H. Snyder, The Principles of Heredity, p. 43.

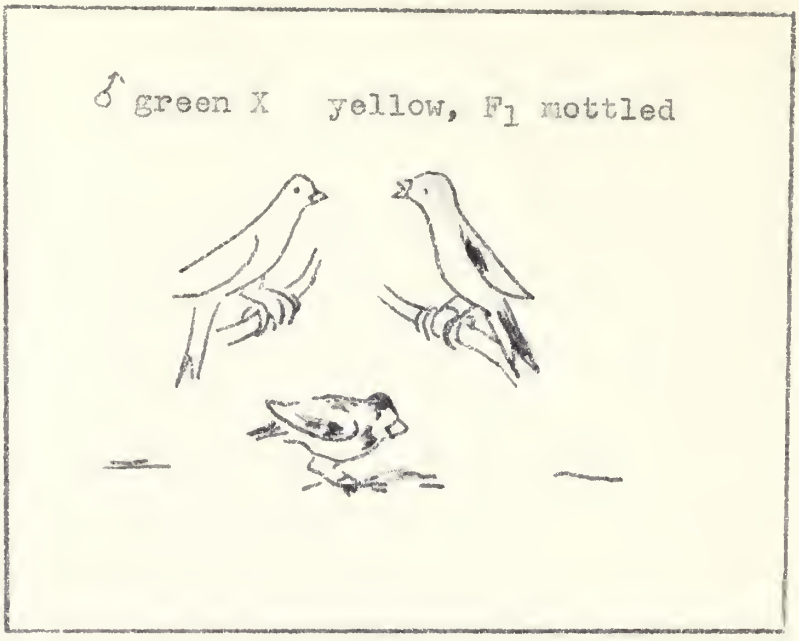

FIGURE 10

Cross: Mottled Canaries

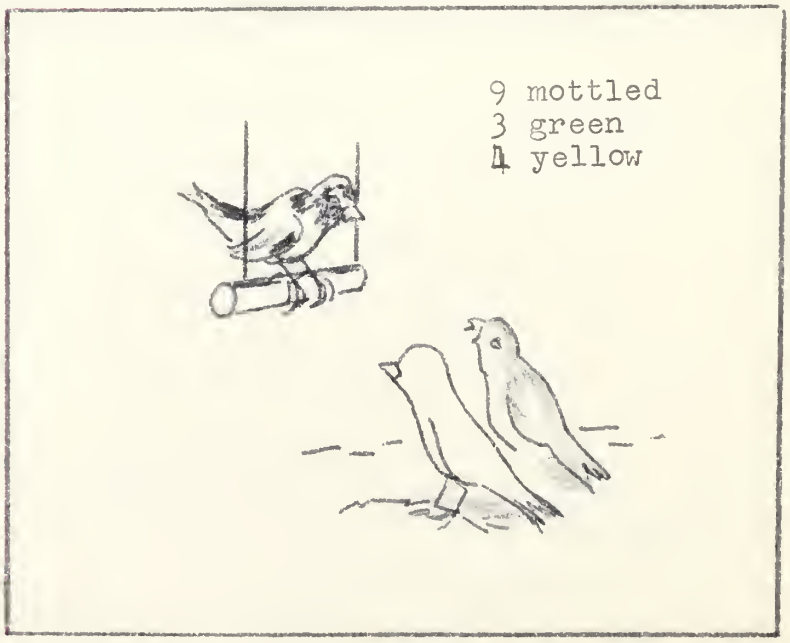

FIGURE 11

Cross: F_2 of Mottled Canaries

During the 250 years in which the domestic canary has been bred, certain characters have been noted which behave after Mendel's laws. The wild canary was green, due to the masking of its yellow pigment by a black pigment. The yellow canary is derived from this original green one by the loss of the black pigment.

Of the factors, crest and non-crest, the former is dominant.[1] When two heterozygous crested canaries are mated, the young are in the ratio of three crested to one non-crested.

When a yellow canary is mated to a pigmented one, all the offspring are mottled, as is shown in figure ten. The degree of mottling is inherited. When two of the mottled canaries are crossed, the F_2 are in a ratio of 9 mottled, 3 green, and 4 yellow.[2] The color possibilities of the F_2 are seen in figure eleven.

Eye color is another factor which behaves in Mendelian fashion. It is determined by a pair of genes, one received from each parent, in which brown is dominant. If both of the genes which the child received are brown, its eyes will be the dominant color, brown. Similarly, if both of the genes for eye color were blue, the eyes will be blue. If

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[1]Charles B. Davenport, Inheritance In Canaries, Carnegie Institution of Washington, Washington, D. C., 1908, p. 23.

[2]Ibid.

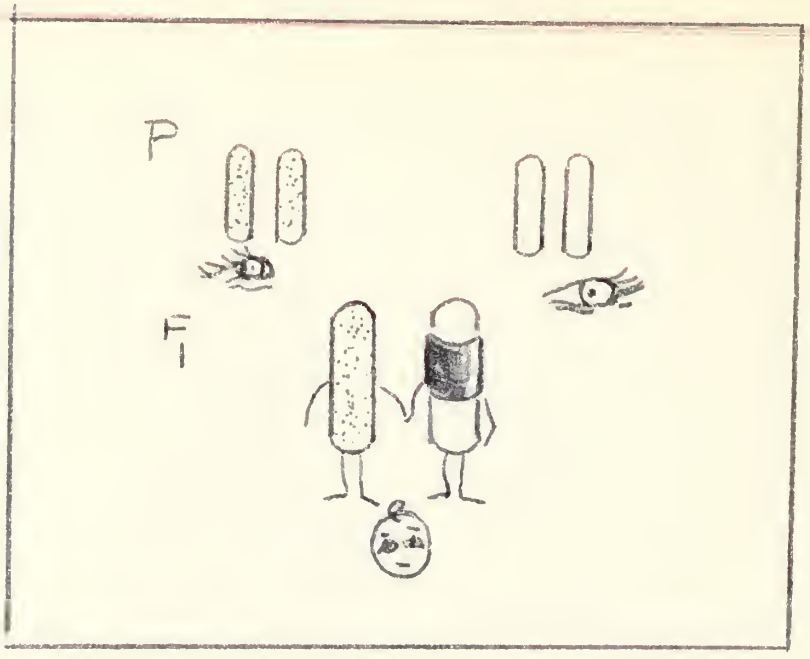

FIGURE 12

Inheritance of Brown Eyes

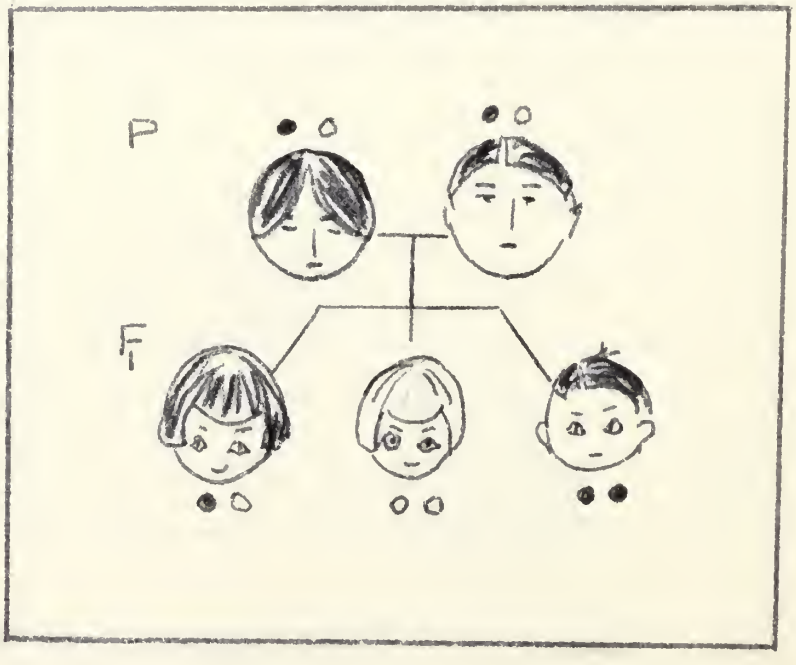

FIGURE 13

Inheritance of Red Hair

one of the genes is for blue and the other for brown, the eye color will be brown. Not a great deal is known about the genetic makeup of green and gray eyes.[1]

In figure twelve a child receiving a blue gene from one parent and a brown one from the other will have brown eyes but carry the gene for blue, which is masked by the heavy brown pigment. Pink or albino eyes are due to a lack of pigment in the iris, so that one sees the blood vessels in back of it.[2]

Dark hair color is also dominant to the lighter colors. A person having dark hair may carry a gene for one of the lighter shades of hair. Red hair color seems to be transmitted independently of the dark melanin pigments and may be totally masked if much melanin is present. It is

> "probably true that a combination of two genes for red hair from two parents always results in red hair. It is also thought that this characteristic is controlled by one red hair gene and one for blond hair which combine from two parents."[3]

It is hard to apply the laws of heredity to this. The effect of red hair is due to dissolved red pigment diffused with scattered pigment granules in the hair shaft.[4] Figure

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[1]Amram Scheinfeld, You and Heredity, p. 56.

[2]Ibid.

[3]Charlotte L. Grant, American High School Biology, Harper & Brothers Publishers, N. Y., 1948, p. 638.

[4]Scheinfeld, op. cit., p. 62.

thirteen shows how it is possible for dark-haired parents to have a child with red hair.

The laws of probability or chance are given in the following sentences.[1] If two persons mate, each carrying one of a mixed pair of genes, the chances are 1 out of 2 times that the child will inherit the dominant gene, and 1 in 2 times it will receive the recessive one. If two persons mate, carrying heterozygous genes for some trait, the chances for each child are:

a. 1 in 4 the child gets both dominant genes.
b. 1 in 4 the child gets both recessive genes.
c. 2 in 4 the child gets 1 dominant gene and 1 recessive gene.

MULTIPLE ALLELES

The word alleles refers to the members of a pair of contrasting factors.[2] Some sets of alleles contain three, four, or more members, but only two of them can occur in a somatic cell. In human beings the different groups of blood, A, B, AB, and O, are inherited on the basis of multiple alleles, containing at least six factors, of which an individual may have any two.[3]

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[1] Amram Scheinfeld, You and Heredity, p. 89.

[2] Laurence H. Snyder, The Principles of Heredity, p. 105.

[3] Ibid., pp. 118-119.

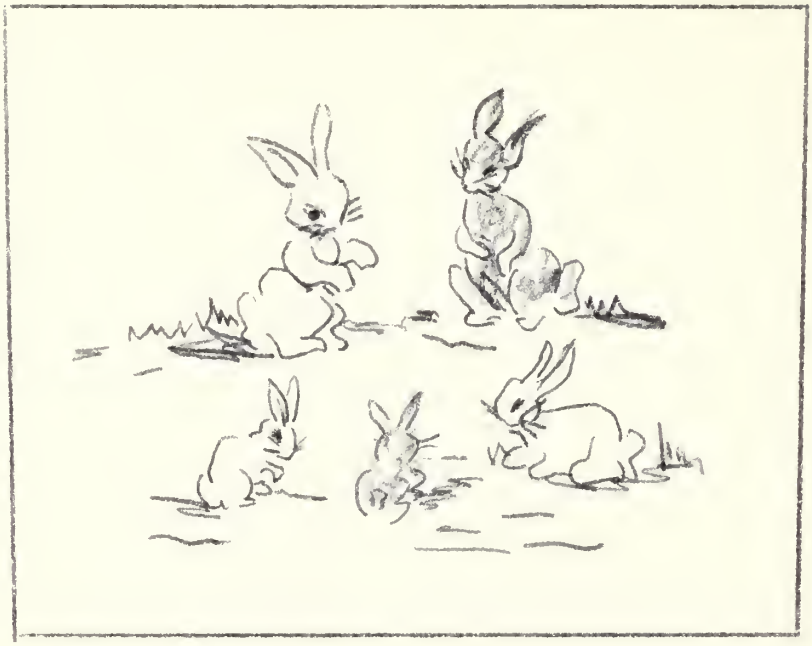

FIGURE 14

Multiple Alleles in the Rabbit

When a cross is made between the small two-three pound Polish rabbit and the Flemish giant rabbit, weighing ten-fourteen pounds, the F_1 are intermediate in size, as can be noted in figure fourteen. In the F_2, variation in size ranges from that of the smallest parent up to as large as the other parent. In cattle the variation of spotting, from a few white patches on solid color to just a trace of color on a white background, is dependent upon multiple factors.[1]

In human beings intelligence, skin color, and height are inherited by means of multiple alleles. In figure fifteen is illustrated possible difference or variation in the height of the children when one parent is very tall and the other is short.

SEX-LINKED FACTORS

In the study of Drosophila it was discovered that it has four pairs of chromosomes, with a noticeable difference in one pair. In the male Drosophila one chromosome, called the Y-chromosome, has a hook on the end, while the other one of the same pair is called the X-chromosome. The female Drosophila has both chromosomes of the X-type. This condition is also true of man. In figure sixteen this is illustrated to show that two X-chromosomes result in a fe-

[1]Laurence H. Snyder, The Principles of Heredity, p. 105.

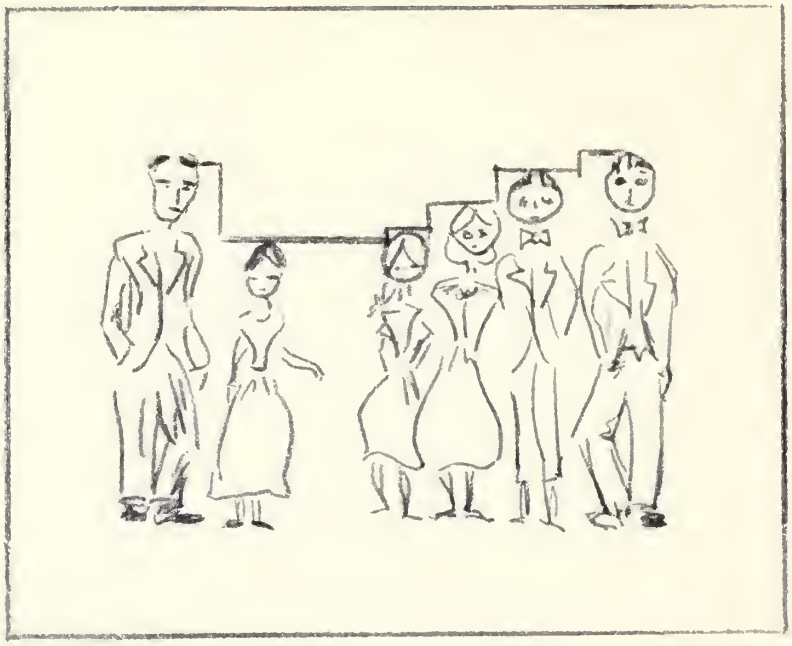

FIGURE 15

Multiple Alleles: Height

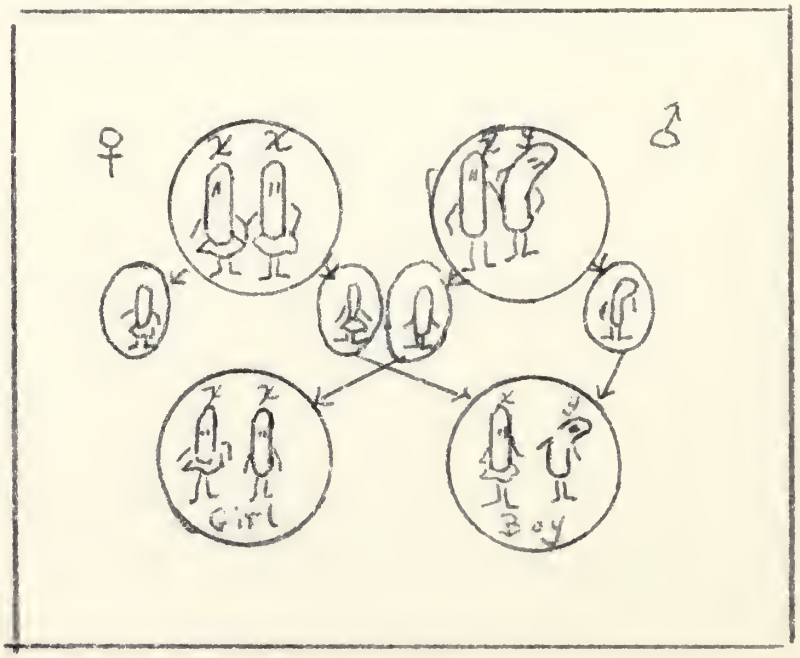

FIGURE 16

XX and XY Chromosomes

male organism while an XY chromosomal pair results in a male.

In birds, Lepidoptera, and some fish, the female has the odd-shaped chromosome and the male has the two X-chromosomes.[1]

Certain factors, carried on the X-chromosomes, are known as sex-linked factors. These sex-linked characters include the white eye of Drosophila. Color blindness and hemophilia are the best-known in man.[2]

A sex-linked factor in the cat is color.[3] The factors for yellow and black are carried on the X-chromosome. Since neither color is dominant, the heterozygote is tortoise shell in color, and usually occurs only in the female. If the female had yellow genes in both X-chromosomes, she would be yellow. Since the male has only one X-chromosome, he will be either yellow or black, depending upon which color is carried on the chromosome. The result of a cross between a tortoise shell cat and a yellow tomcat is shown in figure seventeen.

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[1]Laurence H. Snyder, The Principles of Heredity, p. 81.

[2]Howard Parshley, Biology, John Wiley & Sons, Inc., N. Y. , 1940, p. 143.

[3]William E. Castle, Mammalian Genetics, Harvard University Press, Cambridge, Mass., 4th ed., 1930, p. 156.

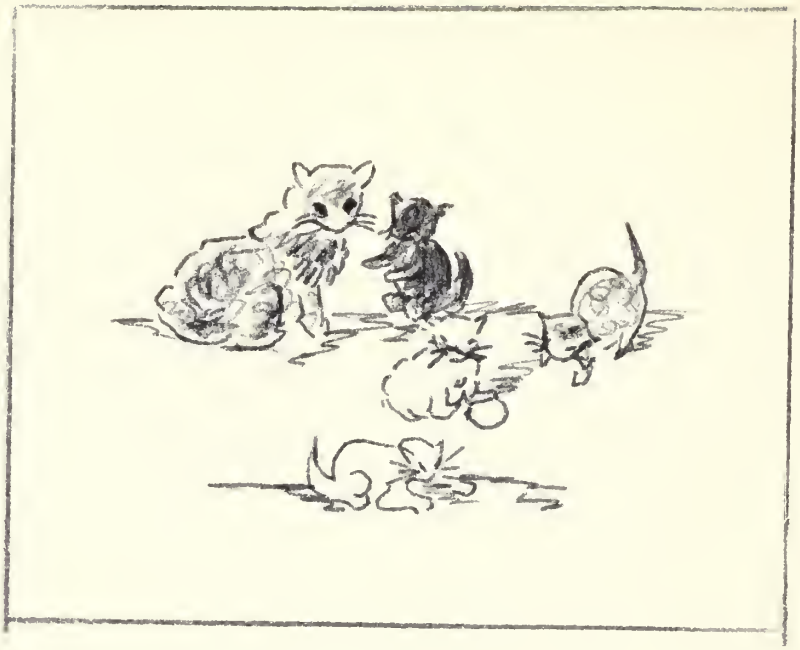

FIGURE 17

Sex-linked Factor--Cat Color

FIGURE 18

Sex-limited Factor--Colias philodice

SEX-LIMITED FACTORS

There are some factors which are expressed in one sex but not in the other. These are called sex-limited factors, and, in mammals and birds, depend upon the presence or absence of one of the sex hormones.[1]

In the clover or common sulphur butterfly, Colias philodice, color is a sex-limited factor. The males are yellow, and the females are either yellow or white. The factor for white is sex-limited to the females. When the gene for white is present, the females are white but the male is always yellow, even when he carries this factor. The white sulphur butterfly of figure eighteen is a female, due to this sex-limited factor, while the yellow ones may be of either sex.

The showy plumage of male birds is due to sex-limited factors, where the factor for cock-feathers is dominant in the male and recessive in the female, and the reverse is true for hen-feathered.[2]

In human beings sex-limited factors also exist. In man, the factor for a beard is dominant, sex-limited to the men, while it is recessive in the women.[3]

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[1] Laurence H. Snyder, The Principles of Heredity, pp. 133-137.

[2] Ibid.

[3] Ibid., pp. 124-128.

SEX-INFLUENCED FACTORS

In some factors dominance depends on sex. One allele or factor will be dominant in the male while the other is dominant in the female. Such factors are known as sex-influenced factors.[1]

An example of this is seen in Ayrshire cattle which are either red-and-white or mahogany-and-white.[2] A homozygous mahogany-and-white male crossed with a red-and-white female had offspring in which the males were mahogany-and-white and the females were red-and-white. If the colors of the parents are reversed, they have offspring with the same results. If two heterozygous F_1 are crossed, the F_2 males are in the ratio of three mahogany-and-white to one red-and-white; while the females are in the ratio of three red-and-white to one mahogany-and-white. The factor for mahogany is dominant in the males while the factor for red is dominant in the female. In figure nineteen are shown mahogany-and-white cattle with their red-and-white daughter.

The inheritance of horns in sheep is similar. The factor for horns is dominant in the male and recessive in the female; while the factor for hornless is dominant in

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[1] Laurence H. Snyder, The Principles of Heredity, p. 125.

[2] Ibid., pp. 124-128.

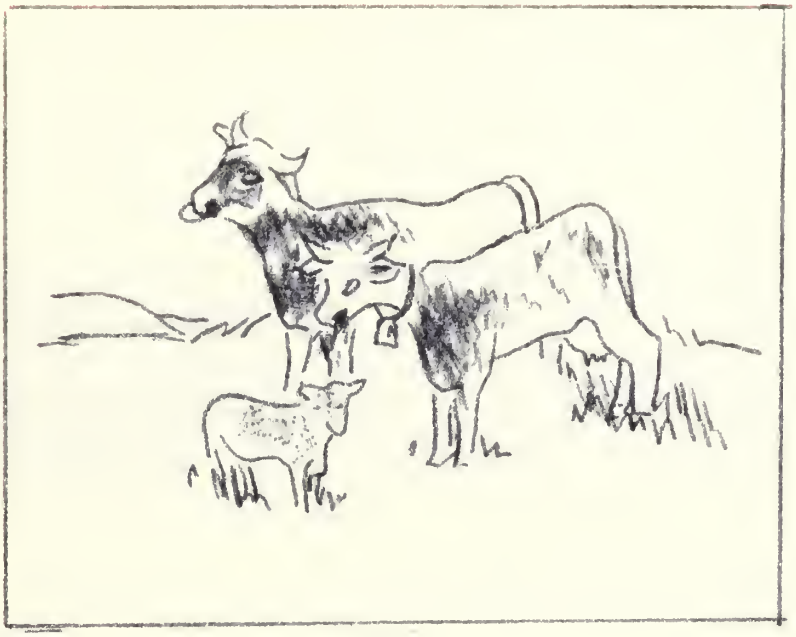

FIGURE 19

Sex-influenced Factor

Mahogany-and-White Cattle

females and recessive in males.

Sex-influenced factors in man include baldness and one form of white forelock.[1] Baldness is more common in men and is transmitted to about one-half of his sons. The factor for baldness is dominant in men and the factor for non-baldness is dominant in women.

> "When we find in human beings a character which is more common in men than in women, which can show up in men when neither parent shows it, which shows up in all the sons of a woman who has it, and which is transmitted directly from a father to approximately half of his sons, we are justified in assuming that the character is dependent on sex-influenced factors."[2]

---

[1]Laurence H. Snyder, The Principles of Heredity, p. 128.

[2]Ibid., p. 130.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The foregoing presentation can be briefly summarized by reviewing the material which has been the content of this paper. The drawings, which are intended to be used as slides, represent some of the possibilities to which the factors of genetics and heredity can be adapted.

The material was introduced with the genes and the chromosomes. This was followed by a discussion of Mendelian inheritance factors; then the multiple factors of height, sex-linked factors, sex-limited ones, and sex-influenced factors.

Conclusions are:

1. Inheritance factors can be adapted for slides.
2. Inheritance factors lend themselves to animation.

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ABSTRACT

VISUAL AIDS IN THE TEACHING OF GENETICS

This problem is concerned with developing a method to effectively present some of the visible effects of inheritance factors in genetics on Slidecraft slides. This was done by using line drawing and color on Slidecraft slides to depict the method of visible inheritance with animation so it can be understood more easily. Slidecraft slides are plastic slides for use in a steropticon. They may be ordered from Meadows A. V. C. Service, 142 Morris Avenue, Mountain Lakes, New Jersey.

The problem was limited to a study of materials and literature in the field of genetics and heredity for items that were suitable for portraying on slides.

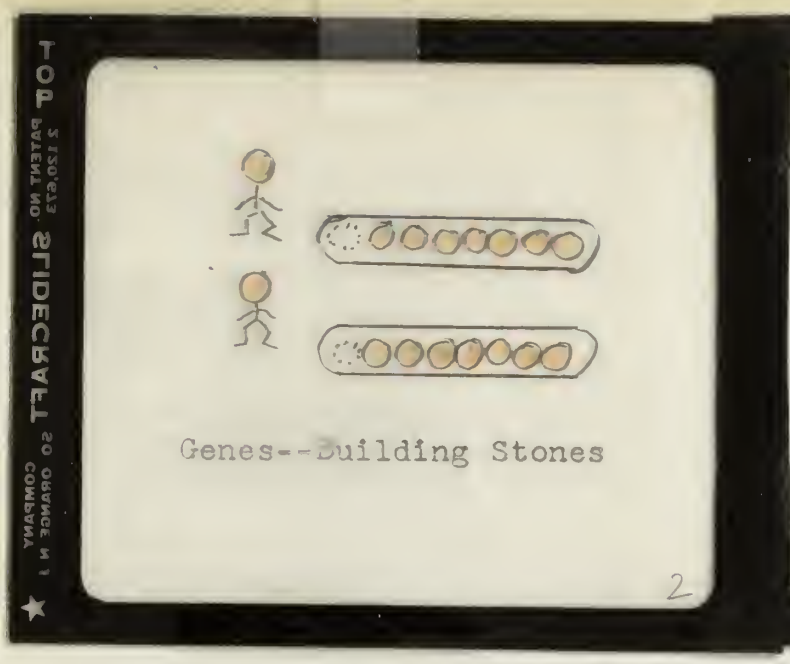
Research procedure consisted of a survey of the available literature on genetics and heredity for material which showed the inheritance of visible factors like eye color, albinism, etc. From these were selected factors which could be illustrated. Animation was applied to the drawings depicting the method of inheritance. The final drawings were made on Slidecraft slides, which are deposited with Dr. John G. Read,

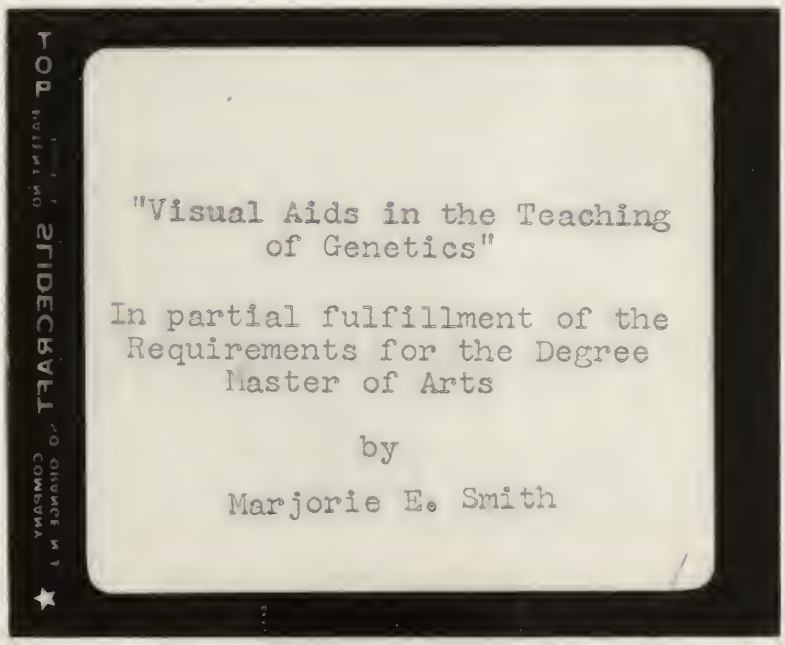
Boston University, School of Education, 332 Bay State Road, Boston, Mass.

The drawings in the thesis, which are duplicates of the slides, can be easily traced on slides if desired. They have been kept as simple as possible; color being added to the slides. The material covered by the slides includes the genes, the chromosomes, Mendelian inheritance, multiple factors, sex-linked factors, sex-limited factors, and sex-influenced factors.

Conclusions are:

1. Inheritance factors can be adapted for slides.
2. Inheritance factors lend themselves to animation.


Genes--Building Stones
2
♀
♂
F1
Child gets ½ its genes from each parent.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In partial fulfillment of the Requirements for the Degree Master of Arts
by
Marjorie E. Smith
1

"Visual Aids in the Teaching
of Genetics"

In partial fulfillment of the
Requirements for the Degree
Master of Arts

by

Marjorie E. Smith

1

PATENT NO.
SLIDECRAFT
COMPANY
SO. ORANGE, N. J.

Cross: yel X green
F_1 mottled

11

9 mottled
3 green
4 yellow

F_2 of
Mottled
Canaries

12

Albino Navaho Girl

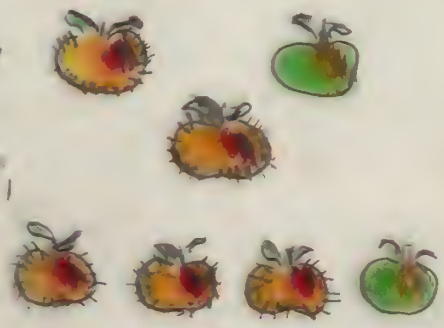
W--white
w--black

P Ww X Ww
F_1 (black)

Black

P

F_1



Cross: Peach X Nectarine

R--red
r--white

P RR X rr
F_L Rr(roan)

Incomplete Dominance

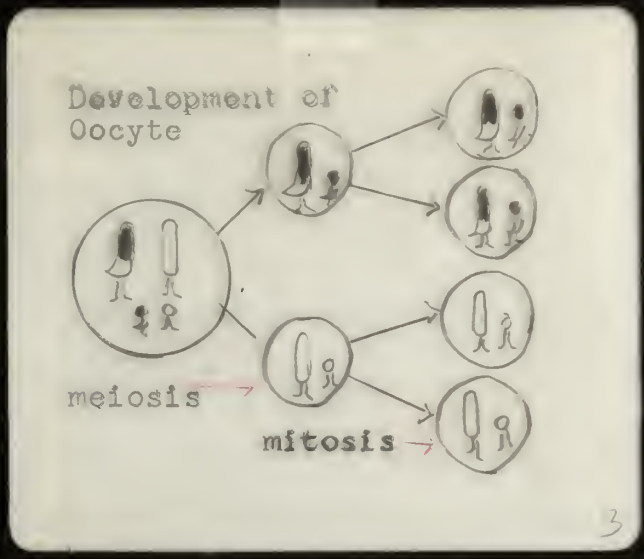
Cross: Yel X Green
F1 mottled
Canaries
Mottled
F2 of
1 Yellow
3 Green
9 mottled

Albino Negro Girl

M--gray
M--white
F1 Mm X Mm
Black sheep

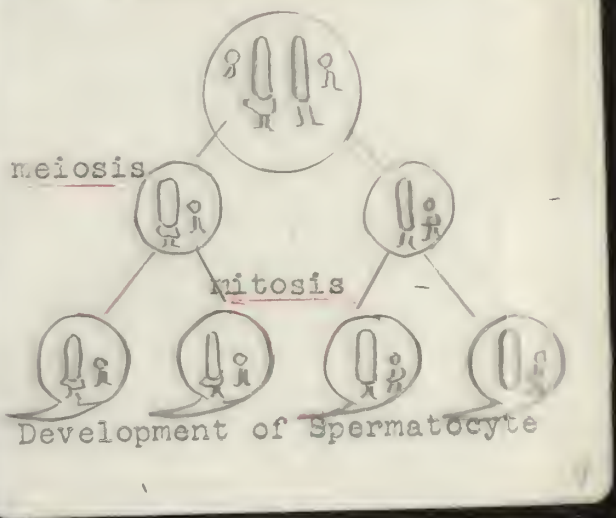
Cross: Peach X Nectarine
P

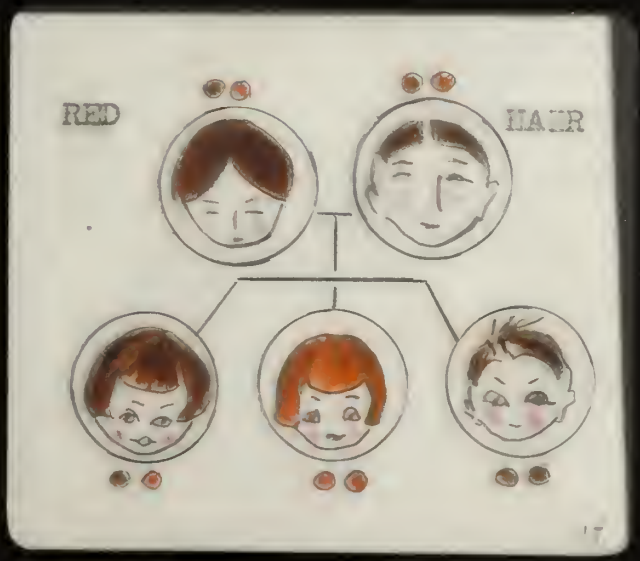
r--white
R--red
F1 Rr(roan)
P RR Xrr
Incomplete Dominance

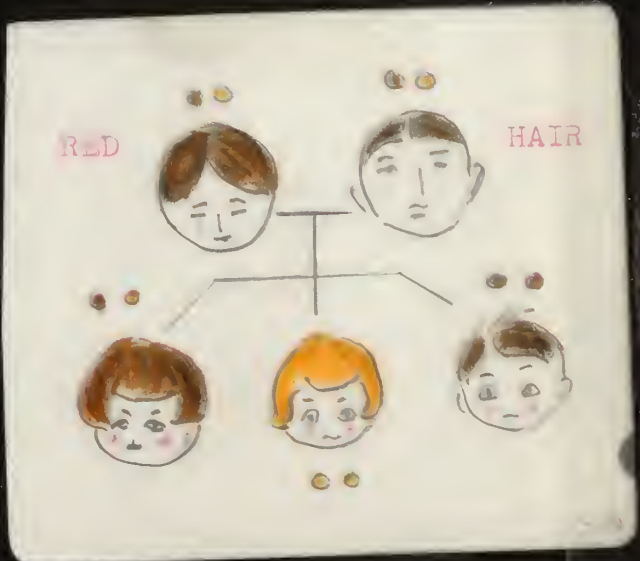

Development of
Oocyte
meiosis
mitosis

Cross
Monozygous Chestnut Horse

Multiple Alleles:


meiosis
mitosis
Development of Spermatocyte


RED
HAIR


RED
HAIR

Cross
Homozygous Chestnut Horse

Development of
Oocyte
meiosis
mitosis

meiosis
mitosis
Development of Spermatocyte

Multiple Alleles:

HAIR
RED

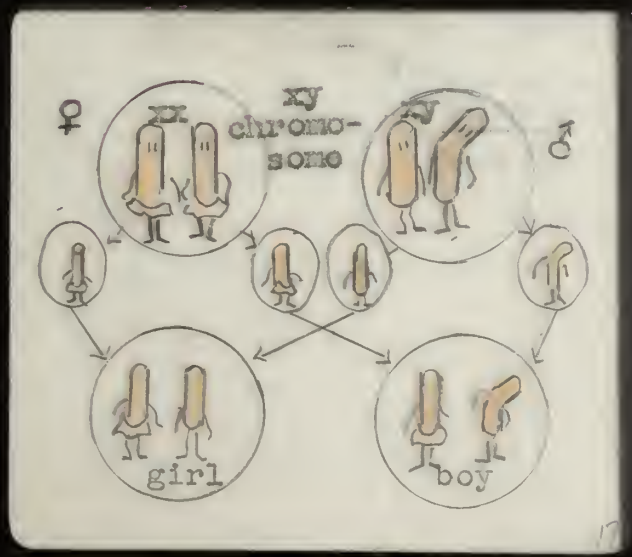
HAIR
RED

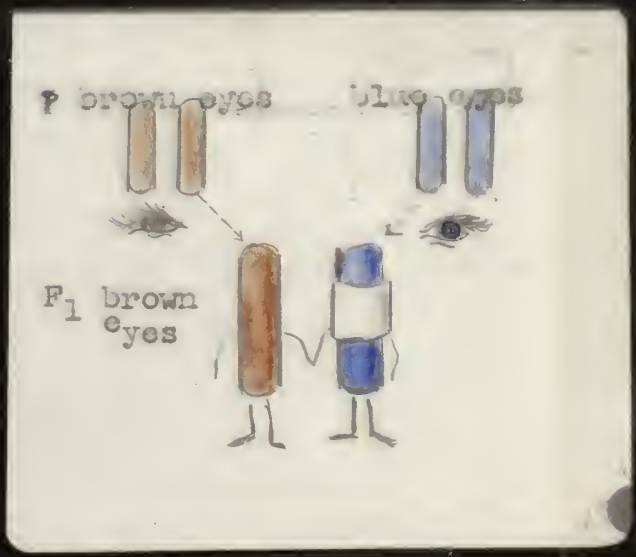
Multiple Alleles: size

P tortoise shell F1
yellow
1 yel ♂
1 yel ♀
1 tortoise
1 black
Sex-
linked
factor

Sex-limited Factor
♂
♀
♀

Sex-influenced Factor
Mahogany-&-White P
Red-&-White ♀ F1
♀


♀
XX
XY
chromo-
some
♂
girl
boy


P brown eyes
blue eyes
F1 brown
eyes

Multiple Alleles: also

Sex-
linked
factor
P tortoise shell F1
yellow
1 yel ♀
1 yel ♂
1 tortoise ♀
1 black ♂

Sex-limited Factor

Sex-Influenced Factor
Hornless ♂ White P
Red-&-White ♀ F1

girl
boy
XX
chromo-
some
XY

F1 brown eyes
P brown eyes blue eyes

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